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OPTIMIZATION OF SOIL AND PLANT INDICES FOR MANAGING POTASSIUM NUTRITION IN GRAPE ORCHARDS OF NORTHERN KARNATAKA

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ABSTRACT
A survey work was carried out in Jamakhandi taluka and selected 60 grape orchards to understand the potassium nutrition and its overall effect on grape production. Based on the quantity of potassium fertilizer used, the grape orchards were categorized into three categories depicting low, medium and high-K users. Contribution of fertilizers to the total K-additions was substantially higher compared to K-inputs from organic sources. The available-K in soils, and petiole-K contents also showed strong relationship to total-K additions. Further, the amount of potassium added was strongly related to soil and petiole K contents and finally to the grape yield and productivity. The results indicated that all the above K- parameters and the grape yields varied significantly in the order of category-3 (high-K users) > category-2 (medium-K users) > category-1 (low-K users) grape orchards. However, the K-productivity factor for grapes among three categories remained in reverse order. Based on grape yield and K-productivity graphs, the optimum-K dose was found to be 1020 kg K_2O ha^{-1}. The study suggested for optimization of K-applications in accordance with petiole-K contents to enhance its use efficiency.

INTRODUCTION

Grape, a sub-tropical fruit believed to have originated from Armenia, is an important fruit crop in Peninsular India. Its cultivation is gaining importance as a most remunerative farming enterprise in northern Karnataka. The crop management has also become intensive with use of more agrochemicals including fertilizers.

Nutrition has a major role in determining grape yields and quality of vineyard (Kranthikumar and Sharma, 2016). Therefore, the nutrients availability in soils and nutrient status in vines must be monitored on a regular basis so as to maintain optimal nutrient status. Imbalanced use of nutrients particularly use of nitrogenous fertilizers alone leads to poor quality of fruits in terms of TSS, colour, keeping quality *etc* (Pal *et al.*, 2015). The importance of K-nutrition in enhancing the quality of fruits and the keeping and marketable quality is well known (Srivastava and Malhotra, 2014). Plants would also become more susceptible to pests and diseases mostly due to excess-N – a scenario which can be countered by optimum K-nutrition. Several studies suggest the role of K in countering the above scenario (Amtmann *et al.,* 2008). Thus, adequate supply of potassium is advisable to meet the physiological functions in the plant. However, there are also reports of over use of potassium in high valued fruit crops especially grapes, pomegranate *etc* (Shikamany *et al*., 1989 and Ganeshamurthy *et al*., 2010). The present nutrition based survey work was done with an aim to assess potassium management in grape orchards so as to understand its effect on grape yields. Finally, this study would also help to identify the optimum soil and plant K-levels so as to manage K-nutrition in grape plantations effectively.

MATERIALS AND METHODS

Study area

Bagalkot district of northern Karnataka provide an ideal climatic conditions and a unique opportunity to cultivate grapes in black soil (Figure 1). Jamakhandi taluka was chosen as an area for the study and sixty grape orchards were chosen randomly for the study.

Data collection

The farmers selected for the study were interviewed through questionnaires to collect information on adopted potassium management practices. The records maintained by them were also used to quantify K-additions from different sources.

Soil sampling and available-K analysis

The soil samples were collected from each selected orchard at three representative points along the rows (at 45 - 60 cm away from the main stem and 45 cm away from the main row) during February and March, 2015. The collected soil samples were mixed thoroughly and made into one composite sample. The samples were air dried, sieved (2 mm) and stored in air tight containers for further analysis. Available potassium content was determined by extracting with neutral normal ammonium acetate (pH 7.0) at 1:5 soil: extractant ratio and the potassium content in soil extract was measured using flame photometer (Jackson 1973).

Petiole collection and K- analysis

Petiole collection was done at 40 to 45 days after 2nd pruning (October, 2015). The leaves present on the opposite of the first inflorescence were chosen for petiole sampling (Patel and Chada, 2002). About 40 - 50 leaves were picked in the morning hours at the rate of 3 - 4 leaves per plant and petioles were retained while, the leaf portion was discarded (Raghupathi, 2011). This procedure was adopted to collect 3 replicates of petioles from each grape orchard. The fresh petioles were washed for 30 seconds sequentially in solutions of 0.1 N HCl, 1 per cent detergent and in pure water (2 times) kept in separate troughs. These washed petioles were dried for a day in shade and then oven dried at 65ºC for 48 hrs. The dried petioles samples were powdered separately and kept in air tight containers for further analysis. The di-acid digested sample was fed to flame photometer directly (with dilutions if necessary) for K readings. The readings were used along with the standards to estimate potassium contents (Piper, 1966).

Grape yield and K- productivity

The farmers were contacted individually to collect the information on grape yields. Yields obtained were translated into fresh grape yields (kg ha^{-1}). Productivity of grapes per unit of added-K was determined by using the formula (Weigh *et al.*, 2011).

$$K - \text{Productivity}(kg / kg\ K20) = \frac{\text{Grape yields(kg per ha)}}{\text{TotalK}_2 0 \text{ added (kg } K_2 0 \text{ per ha)}}$$

Data analysis

The grape orchards were categorized into three categories namely, category-1, category-2 and category-3 orchards based on potassium additions using K-means clustering technique. The significance of difference in soil-K, petiole-K, yield and productivity of the above 3 categories was tested using standard statistical tools (Katyal and Hegde, 2013).

RESULTS AND DISCUSSION

Quantity of potassium application to grape orchards through fertilizers and organic manures differed to a greater extent (Figure 2). The amount of potassium applied through fertilizers varied significantly among the three categories in the order: category-3 (1141.3 ± 84.5 kg K_2O ha^{-1}) > category-2 (945.8 ± 47.9 kg K_2O ha^{-1}) > category- 1 (783.4 ± 58.4 kg K_2O ha^{-1}). However, the amount of potassium added through organic manure remained non-significant and the corresponding values for three categories were found to be 98.0 ± 28.5 kg K_2O ha^{-1} in category-1; 96.5 ± 31.6 kg K_2O ha^{-1} in category-2

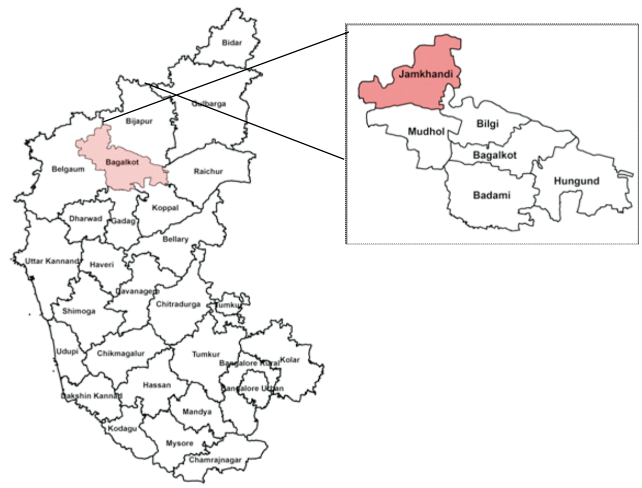

Figure 1: Location of the study area

and 98.8 ± 27.2 kg K_2O ha^{-1} in category-3 grape orchards. The results suggested that the fertilizer was the key component of K-nutrition in grape orchards in Mudhol taluka. In terms of total-K used, category-1 grape orchards recorded significantly lower amounts with 881.4 ± 58.2 kg K_2O ha^{-1} while, category-2 and -3 orchards added 1042.3 ± 62.0 kg K_2O ha^{-1} and 1240.05 ± 82.0 kg K_2O ha^{-1} respectively. Thus, the order of total-K used among 3-categories of grape orchards was similar to that of added fertilizer-K. Similar reports on high use of K-fertilizers in grape nutrition have been made by Kapoor *et al.* (1981), Yogeeshappa, (2007) and Anita (2016).

The available soil potassium content of three categories of grape orchards ranged from 574.9 kg K_2O ha^{-1} in category-1 grape orchards to 873.9 kg K_2O ha^{-1} in category-3 grape orchards (Table 1). All the soil samples showed higher range of potassium availability (> 336 kg K_2O ha^{-1}). The order of available-K_2O among the categories was similar to the order of K-addition *i.e.*, category-3 > category-2 > category-1 indicating the positive effects of K-applications on its availability in soil (Table 1).

Higher availability of potassium in the orchards could be attributed to basic nature of black soils (Yeresheemi *et al.*, 1999) and high use of K-fertilizers in grape orchard (Sharma *et al.,* 2004 and Ganeshamurthy *et al.* 2010). The effect of K-application was also evident in terms of its effect on available-K contents (r = 0.764**). Similar observations on higher potassium availability in grape orchards existing in black soils have been reported by Pujar *et al.* (2010) and Anita (2016).

The grapes grown with different levels of K-additions showed variations in petiole-K contents (Table 1). It was found significantly high in category-3 orchards (3.10 %) compared to category-2 (2.65 %) and category–1 (2.41 %). The petiole-K contents also showed significant positive relations with

Table 1: Productivity related parameters in three categories of grape orchards

Grape orchard category	Soil available- K(kg K_2Om ha^{-1})	Petiole- K (%)	Grape yield(t ha^{-1})	Productivity(kg kg^{-1} K_2O)
Category-1 (n = 25)	574.9 ± 96.5^a	2.41 ± 0.34^a	23.24 ± 1.53^a	29.77 ± 2.42^a
Category-2 (n = 25)	654.7 ± 108.9^b	2.65 ± 0.38^b	25.73 ± 1.81^b	26.92 ± 2.16^b
Category-3 (n = 10)	873.9 ± 60.5^c	3.10 ± 0.44^c	26.57 ± 1.79^c	24.10 ± 2.21^c
SEm ±	41.33	0.16	0.73	0.97
CD at 5%	69.05	0.26	1.20	1.61

Table 2: Correlation coefficients for different parameters in grape orchards

Parameters	Fertilizer-K	Manure- K	Total added -K	Available-K	Petiole-K	Grape Yield	Grape Productivity
Fertilizer-K	1.000						
Manure- K	-0.033	1.000					
Total added -K	0.979**	0.172	1.000				
Available-K	0.761**	0.069	0.764**	1.000			
Petiole-K	0.676**	-0.014	0.663**	0.587**	1.000		
Grape Yield	0.585**	0.132	0.604**	0.477**	0.413**	1.000	
Grape Productivity	-0.774**	-0.106	-0.784**	-0.576**	-0.495**	-0.218	1.000

Note- ** Significant at 1 %

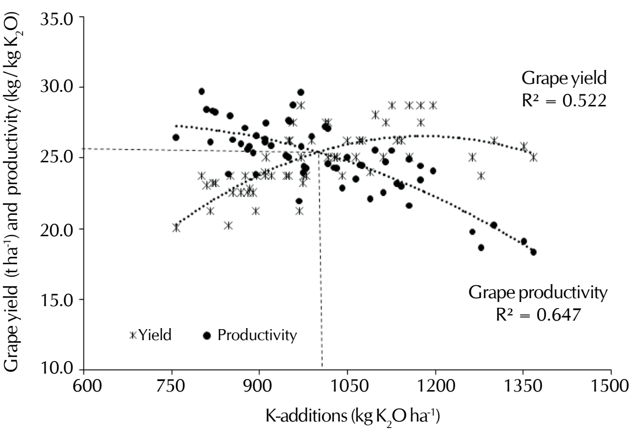

Figure 2: The response of grape in terms of its yield and productivity to potassium additions

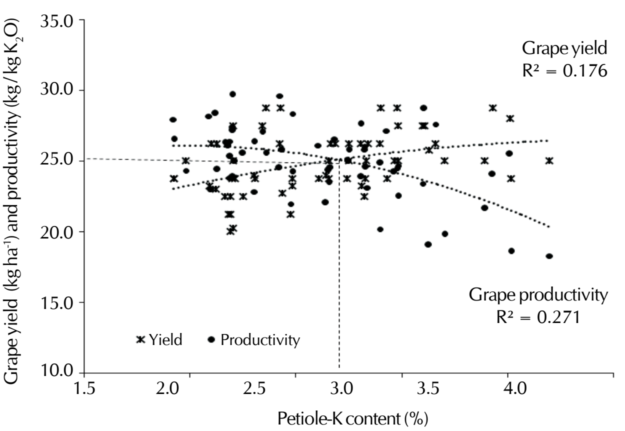

Figure 3: The response of grape yield and productivity in response to its Petiole-K contents

added-K (r = 0.663**) and similar results were reported earlier by Bharghava and Raghupati (2001) and Ganeshmurthy *et al.* (2010).

The grape yields obtained in different categories of orchards are presented in Table 1 and it ranged from 23.24 to 26.57 t ha^{-1}. The grape yields in category-1 orchards were significantly lower (23.24 $\pm$ 1.53 t ha^{-1}) compared to category-2 (25.42 $\pm$ 1.70 t ha^{-1}) and category-3 (26.57 $\pm$ 1.79 t ha^{-1}). Thus, the grape yields varied distinctly in the order of category-3 > category-2 > category-1 grape orchards. The grape yields and K-additions showed curvilinear relationship with yield increase up to 1150 kg K_2O ha^{-1} and declined with further increase in K-applications (Figure 2). The relationships of K-additions (fertilizer + manure), soil available-K and petiole-K contents showed significant positive correlations with grape yields (Table 2).

The difference in yields could be attributed to variations in soil nutrient availability as determined by nutrient applications (Bhargava and Sumner, 1987). High amounts of nutrient applications is known to increase its availability in soil and hence, the plant uptake (Shikamany *et al.*, 1989 and Ganeshamurthy *et al.*, 2010). The diagrammatic representations of the relationships between grape yields with added-K contents (Figure 2) and with petiole- K content (Figure 3) showed positive relationships further strengthening the above observations. On the other hand, the grape productivity per unit K-added (kg kg^{-1} K_2O) was found in the reverse order and was in the order of category 1 > category 2 > category 3 grape orchards *ie* category 1 recorded higher productivity of 29.77 $\pm$ 2.42 kg kg^{-1} K_2O compared to category 2 (26.92 $\pm$ 2.16) and category 3 (24.10 $\pm$ 2.21) grape orchards. The applied-K increased petiole-K contents indicating its uptake however, the grape productivity declined suggesting its luxurious uptake without its contribution to the yield. Luxury consumption of potassium in horticultural crops is well established (Ramanathan, 2011). These results suggest that there is a need to optimize K-applications by matching the grape productivity with K-additions and petiole-K contents.

In this regard, the yield and productivity trend curves were plotted against the total-K additions (Figure 2) and the optimum-K dose was found around 1000 kg K_2O ha^{-1}. Similarly, the grape yields and productivity values were plotted against petiole-K contents (Figure 3). The intersection point of yield and productivity trend curves of grape coincides with the petiole-K content at 2.75 per cent suggesting optimum petiole-K value for sustainable grape yields. These observations indicate that the farmers in category-1 are applying K-fertilizers below the optimum level, whereas the farmers in category-3 are using excess-K. Incidentally, the optimum-K addition value (fertilizer + FYM) in grape orchards is very close to the fertilizer recommendations of 1000 kg K_2O ha^{-1} in the state. Similarly, the optimum petiole-K value was within the optimum range of 2.50 to 2.80 per cent prescribed by Indian Institute of Horticultural Research, Bangalore. This comprehensive study on grape in Jamakhandi suggests that the farmers need to be educated on adoption of petiole-K analysis to add optimum quantities of K-nutrient (through fertilizers + FYM) to achieve good grape yields sustainably.

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